# The single-path standard deviation derived from ground motion records in Japan

*引田 智樹[1]、纐纈 一起[2]、三宅 弘恵[3]
*Tomoki Hikita[1], Kazuki Koketsu[2], Hiroe Miyake[3]

1. 鹿島建設株式会社、2. 東京大学地震研究所、3. 東京大学大学院情報学環総合防災情報研究センター
1. Kajima Corporation, 2. Earthquake Research Institute, University of Tokyo, 3. Center for Integrated Disaster Information Research, Interfaculty Initiative in Information Studies, University of Tokyo

1. Introduction
The amplitude of a ground motion record includes aleatoric variability, even if the records observed at one site by the earthquakes with same magnitude and same location. It is important to clarify the characteristics of such variability in order to understand the accuracy of earthquake ground motion prediction. Using ground motion records from dense networks, several recent studies (e.g. Anderson and Uchiyama, 2011; Lin et al., 2011) have estimated the single-path standard deviations by removing ergodic assumption. Those studies are based on the difference between observed ground motion amplitude and a ground motion prediction model. Estimated variabilities may be affected by modeling error of applied ground motion prediction model. In this study, the single-path standard deviation have investigated directly from the amplitude ratio of pairs of ground motion records observed at one site by two earthquakes with same magnitude and same location.
2. Data and Method
The amplitude ratios of pairs of ground motion records by two earthquakes have been investigated. The two earthquakes satisfy the following conditions. 1) JMA magnitudes ($M_J$) are the same. 2) Focal mechanisms are similar. 3) Distance between hypocenters is 3 km or less. Pairs of ground motion records of K-NET and KiK-net by two earthquakes have been used. Hypocentral distances of records are 5 or more times of the distance between hypocenters of two earthquakes, and 200km or less. Maximum acceleration of the records at free-field exceeds 1 $cm/s^2$. As a result, 39,103 pairs of record by 696 pairs of earthquake were used for this study. The single-path standard deviation (*sigma*) estimated by variance of the natural logarithmic acceleration response spectrum ratio (*v*) of record pairs. *sigma*=$(\mathrm{Var}[v]/2)^{0.5}$.
The acceleration response spectrum was averaged of two horizontal components.
3. Results
Estimated *sigma* from all data was about 0.3 - 0.45 (Fig. 1). This result at period of 0.02 s was consistent with single-path standard deviations for maximum acceleration from previous studies (Morikawa et al., 2008; Lin et al., 2011). In Fig. 1, *sigma* was slightly large around the period of 0.2 s. According to comparison of *sigma* estimated from data of every magnitude range, the dominant period of *sigma* moved to the longer period depending on magnitude (Fig. 2). Since site and propagation path of each record pairs are the same respectively, the main factor of *sigma* is considered to be the differences in the source characteristics of two earthquakes. If the rupture processes of two earthquakes are different, the within-event variability of pairs of records from two earthquakes may be large around corner frequencies of two earthquakes. The dominant period of *sigma* from large earthquakes was longer than that from small earthquakes. The logarithms of the dominant period of *sigma* were proportional to about $0.4M_J$ (Fig. 3). Those characteristics of *sigma* indicate that the uncertainty of rupture process is one of the factors in single-path standard deviation.

キーワード：地震動、応答スペクトル、ばらつき、不確実性

 

Keywords: ground motion, response spectrum, variability, uncertainty

 

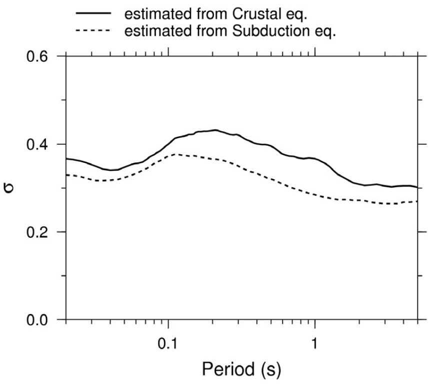


Fig. 1 Estimated single-path standard deviation $\sigma$. Solid line shows $\sigma$ from data by crustal earthquakes. Dotted line shows $\sigma$ from data by subduction earthquakes.

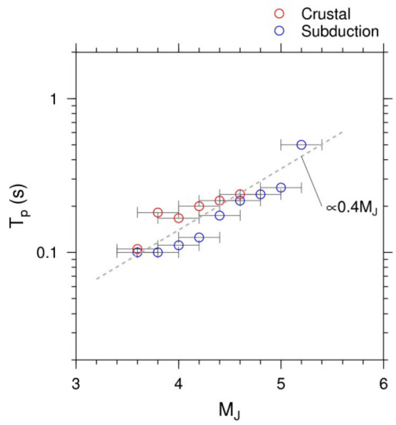


Fig. 3 Dominant period ($T_p$) of single-path standard deviation from data of every magnitude range. Red circle and blue circle shows $T_p$ from data by crustal earthquakes and subduction earthquakes. Dotted line shows the approximate slope to $M_J$.

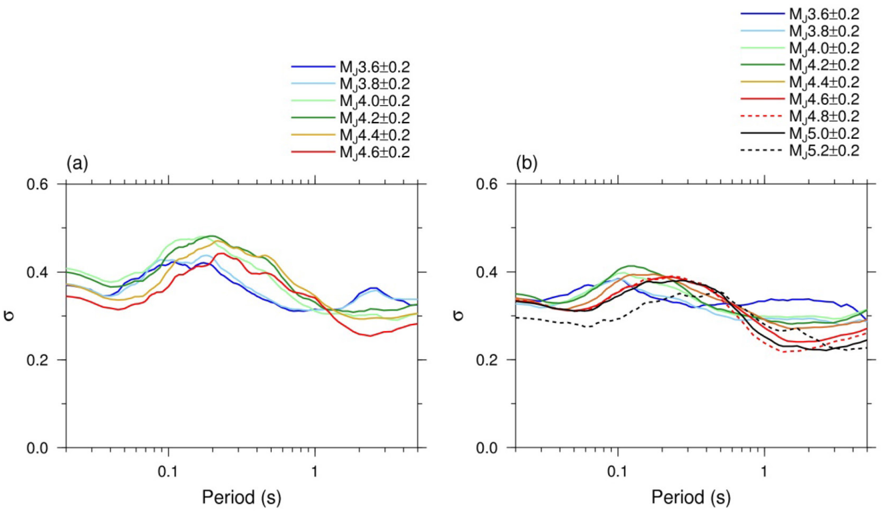


Fig. 2 Single-path standard deviation $\sigma$ estimated from data of every magnitude range. (a) $\sigma$ from data by crustal earthquakes. (b) $\sigma$ from data by subduction earthquakes.